List of cited reference of 03/23/2004

Document	*mm/dd/yyyy*	*Inventor*	*Classification*
PCT/US99/13362 (US 09/098,294)	06/15/1998	Tang, Weiming et al	B60 R 22/12

I own only a few pages of PCT/US99/13362 (US 09/098,294) which disclose and illustrate the elongation rate dependent from the force.

The accident report "U260901" was already submitted to USPTO.

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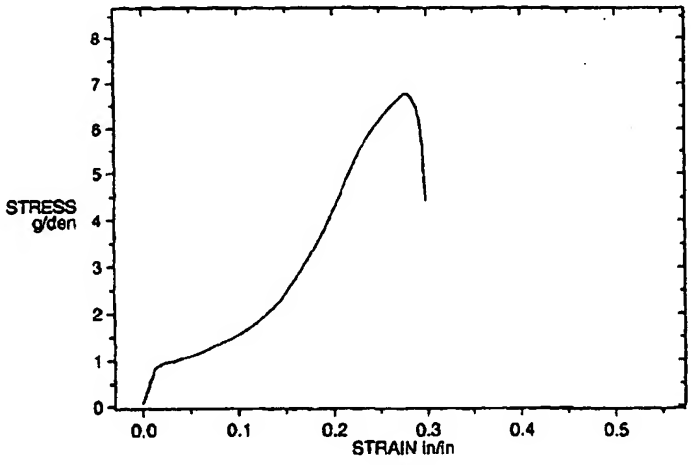
(54) Title: LOAD LIMITING WEBBING



(57) Abstract

The present webbing has a force–displacement profile characterized by: (a) when the webbing is subjected to a knuckle point force in the range from about 400 pounds (about 1.8 kilonewtons) to about 900 pounds (about 4.0 kilonewtons), the webbing elongates to less than about five percent; (b) upon subjecting the webbing to greater than the knuckle point force and to less or equal to about 1,400 pounds (about 6.2 kilonewtons), the webbing elongates further to at least about ten percent; and (c) upon subjecting the webbing to greater than 1,400 pounds (about 6.2 kilonewtons), the modulus increases sharply and the webbing elongates further until the webbing breaks at a tensile strength of at least about 5,000 pounds (about 22 kilonewtons). The present webbing is useful for seat belts, parachute harnesses and lines, shoulder harnesses, cargo handling, safety nets, trampolines, safety belts or harnesses for workers at high altitudes, military arrestor tapes for slowing aircraft, ski tow lines, and in cordage applications such as for yacht mooring or oil derrick mooring.

LOAD LIMITING WEBBING

Background of the Invention

A typical vehicle safety seat belt system is designed to restrict the displacement of an occupant with respect to the occupant's seated position within the vehicle when the vehicle experiences a sudden, sharp deceleration. (See U.S. Patent 3,322,163). A typical seat belt has three main portions: the retractor belt, the torso belt, and the lap belt and the performance of each belt may be characterized by its force-displacement curve. The area under the force-displacement curve is referred to as the energy absorbed by the safety restraint.

Current vehicle safety seat belts are made from fully drawn polyethylene terephthalate ("PET") fiber which is partially relaxed (2.7%) and having a tenacity of at least 7.5 grams/denier and 14% elongation at break. U.S. Government regulation requires that seat belts must withstand loads up to 6,000 lbs. However, a problem exists with the current PET fiber based seat belts. Crash studies indicate that after the initial vehicle impact occurs (e.g. at a speed of about 35 miles/hour), the occupant tends to move forward from his seated position until the belt engages to build restraining forces. As indicated in Figure 1, the relatively unyielding belt made from PET fiber exerts a force of at least 2,000 pounds (about 9,000 Newtons) against the occupant at the seat belt torso position so as to cause the occupant to have high chest, rib cage, head, neck, and back injuries when the occupant rebounds and impacts the back structure of the seat assembly.

When a car collides at a speed of 35 miles/hour, an impact energy to which an average sized person in the car is subjected is at least 500 Joules on the torso belt. Although the current PET fiber may absorb the impact energy, damage to the vehicle occupant still occurs due to the undesirable fiber force-displacement curve. In 70 milliseconds, an average sized

passenger will experience high forces of up to 2,000 pounds (about 9,000 Newtons) as shown in Figure 1.

In order to absorb the impact energy and to reduce the seat belt load against the vehicle occupant, U.S. Patent 3,550,957 discloses a shoulder harness having stitched doubled sections of the webbing arranged above the shoulder of the occupant so that the stitching permits the webbing to elongate from an initial length toward a final length at a controlled rate under the influence of a predetermined restraining force. However, the stitched sections do not give the desirable amount of energy absorption, do not provide uniform response, and are not reusable in multiple crashes. See also U.S. Patent 4,138,157.

U.S. Patent 3,530,904 discloses a woven fabric which is constructed by weaving two kinds of yarns having relatively different physical properties and demonstrates energy absorption capability. U.S. Patents 3,296,062; 3,464,459; 3,756,288; 3,823,748; 3,872,895; 3,926,227; 4,228,829; 5,376,440; and Japanese Patent 4-257336 further disclose webbings which are constructed of multiple kinds of warp yarns having different tenacity and elongations at break. DE 19513259A1 discloses webbings which are constructed of short warp threads which will absorb the initial tensile load acting on the webbing and also longer warp threads which will absorb the subsequent tensile load acting on said webbing.

Those skilled in this technical area have recognized the deficiencies in using at least two different yarn types as taught by the preceding references. U.S. Patent 4,710,423 and Kokai Patent Publication 298209 published on December 1, 1989 ("Publication 298209") teach that when using at least two different yarn types, energy absorption occurs in a stepwise manner and thus, the web does not absorb the energy continuously and smoothly. Therefore, after one type of warps absorbs a portion of the impact

energy, and before another type of warps absorbs another portion of the impact energy, the human body is exposed to an undesirable shock.

UK Patent 947,661 discloses a seat belt which undergoes an elongation of greater than or equal to 33 percent when subjected to at least 70% of the breaking load. This reference does not teach or suggest the present load limiting yarn.

U.S. Patent 3,486,791 discloses energy absorbing devices such as a rolled up device which separates a slack section of the belt from the taut body restraining section by clamping means which yield under a predetermined restraining force to gradually feed out the slack section so that the taut section elongates permitting the restrained body to move at a controlled velocity. The reference also describes a device which anchors the belt to the vehicle by an anchor member attached to the belt and embedded in a solid plastic energy absorber. These kinds of mechanical devices are expensive, are not reusable, provide poor energy absorption, and are difficult to control. An improvement on the foregoing devices is taught by U.S. Patent 5,547,143 which describes a load absorbing retractor comprising: a rotating spool or reel, seat belt webbing secured to the reel; and at least one movable bushing, responsive to loads generated during a collision situation, by deforming a portion of the reel and in so doing dissipating a determined amount of the energy. This kind of mechanical device is built-in with a specific amount of load limiting and energy absorption towards certain sized occupants, and cannot be adjusted to the needs of different sized occupants in real transportation scenario. Furthermore, this kind of mechanical device is not reusable to limit the load in multiple crashes since the reel is deformed permanently in the first vehicle collision.

U.S. Patent 4,710,423 and Publication 298209 disclose webbing comprised of relaxed polyethylene terephthalate ("PET") yarns having tenacity

Figure 6 illustrates the performance (with load as a function of time) of the load limiting webbing of the present invention at the torson position in a vehicle collision.

DETAILED DESCRIPTION OF THE INVENTION

Referring to Figure 2, the present invention provides a webbing having a force-displacement profile characterized by:

(a) when the webbing is subjected to a knuckle point force in the range from about 400 pounds (about 1.8 kilonewtons) to about 900 pounds (about 4.0 kilonewtons), the webbing elongates to less than about five percent;

(b) upon subjecting the webbing to greater than the knuckle point force and to less or equal to about 1,400 pounds (about 6.2 kilonewtons), the webbing elongates further to at least about ten percent; and

(c) upon subjecting the webbing to greater than 1,400 pounds (about 6.2 kilonewtons), the modulus increases sharply and the webbing elongates further until the webbing breaks at a tensile strength of at least about 5,000 pounds (about 22 kilonewtons).

The webbing is made from yarn spun from a polymer having a glass transition temperature in the range from preferably about -40°C to

WHAT IS CLAIMED IS:

1. A webbing having a force-displacement profile characterized by:

(a) when said webbing is subjected to a knuckle point force in the range from about 400 pounds (about 1.8 kilonewtons) to about 900 pounds (about 4.0 kilonewtons), said webbing elongates to less than about five percent;

(b) upon subjecting said webbing to greater than said knuckle point force and to less or equal to about 1,400 pounds (about 6.2 kilonewtons), said webbing elongates further to at least about ten percent; and

(c) upon subjecting said webbing to greater than 1,400 pounds (about 6.2 kilonewtons), the modulus increases sharply and said webbing elongates further until said webbing breaks at a tensile strength of at least about 5,000 pounds (about 22 kilonewtons).

2. The webbing of claim 1 wherein in part (a), said webbing elongates to less than about three percent.

3. The webbing of claim 1 wherein in part (b), said webbing elongates to at least about 15 percent.

4. The webbing of claim 1 wherein said webbing is made from yarn having a force-displacement profile characterized by:

a) when said yarn is subjected to an initial stress barrier of from about 0.8 gram/denier to less than or equal to about 1.2 grams/denier, said yarn elongates to less than 5 percent and has an initial modulus in the range from about 30 grams/denier to about 80 grams/denier;

b) upon subjecting said yarn to greater than said initial stress barrier and to less than or equal to about 1.5 grams/denier, said yarn elongates further to at least about 8 percent; and

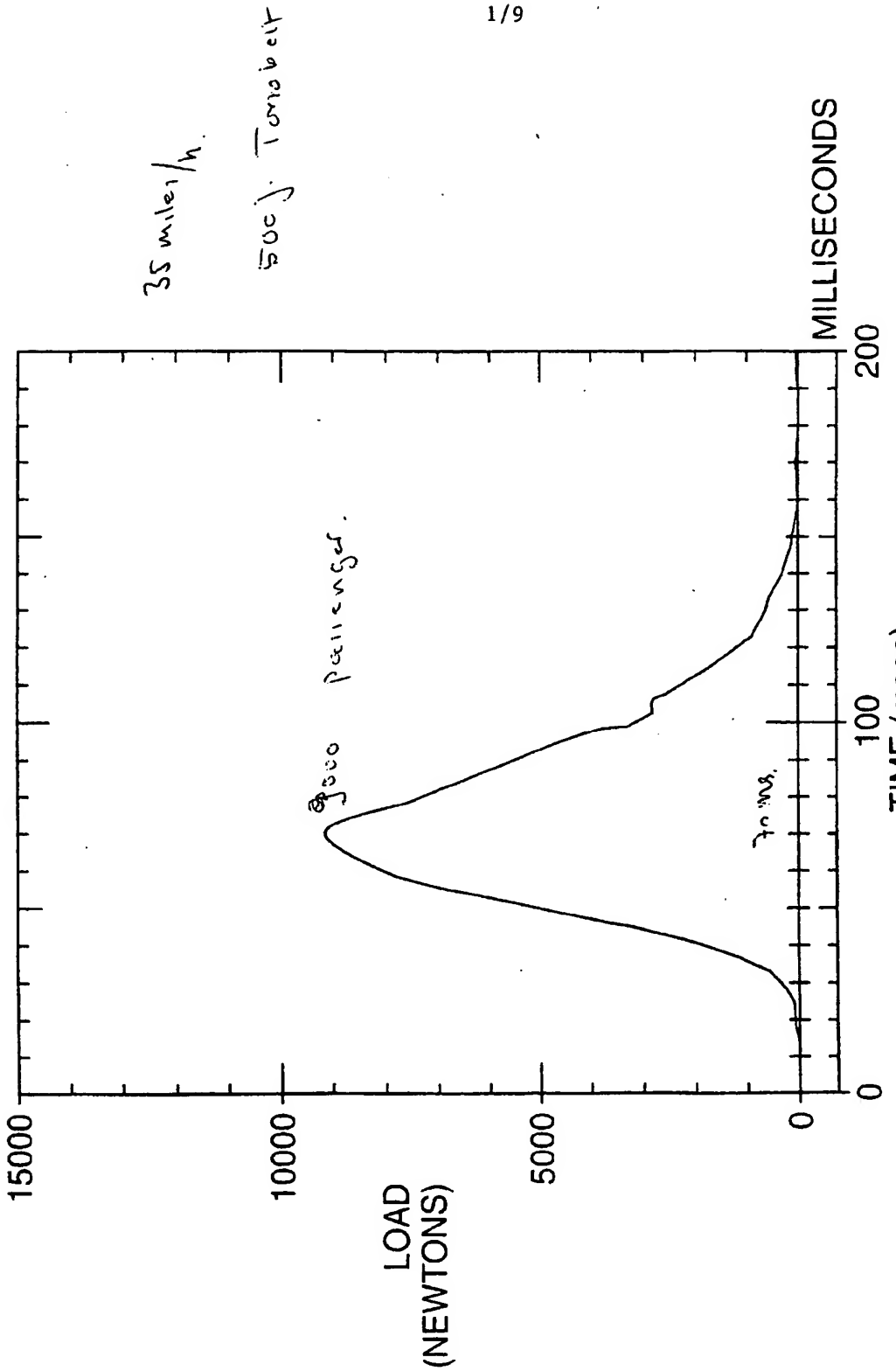

35 miles/h.
50 c.j. Tomahawk
LOAD (NEWTONS)
15000
10000
5000
0
0
100
200
TIME (msec)
MILLISECONDS

FIG. 1

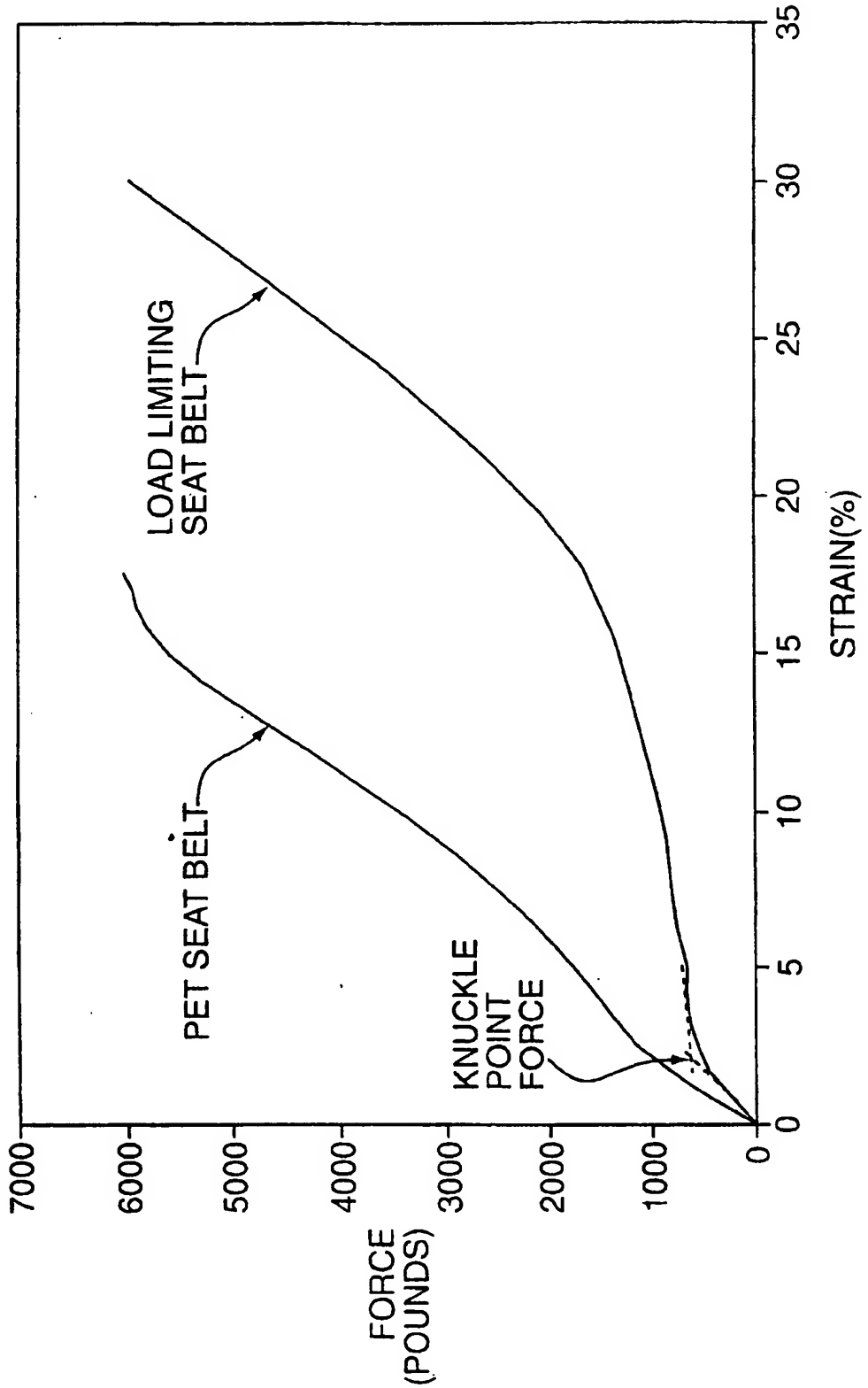

LOAD LIMITING SEAT BELT
PET SEAT BELT
KNUCKLE POINT FORCE
FORCE (POUNDS)
7000
6000
5000
4000
3000
2000
1000
0
0
5
10
15
20
25
30
35
STRAIN(%)

FIG. 2

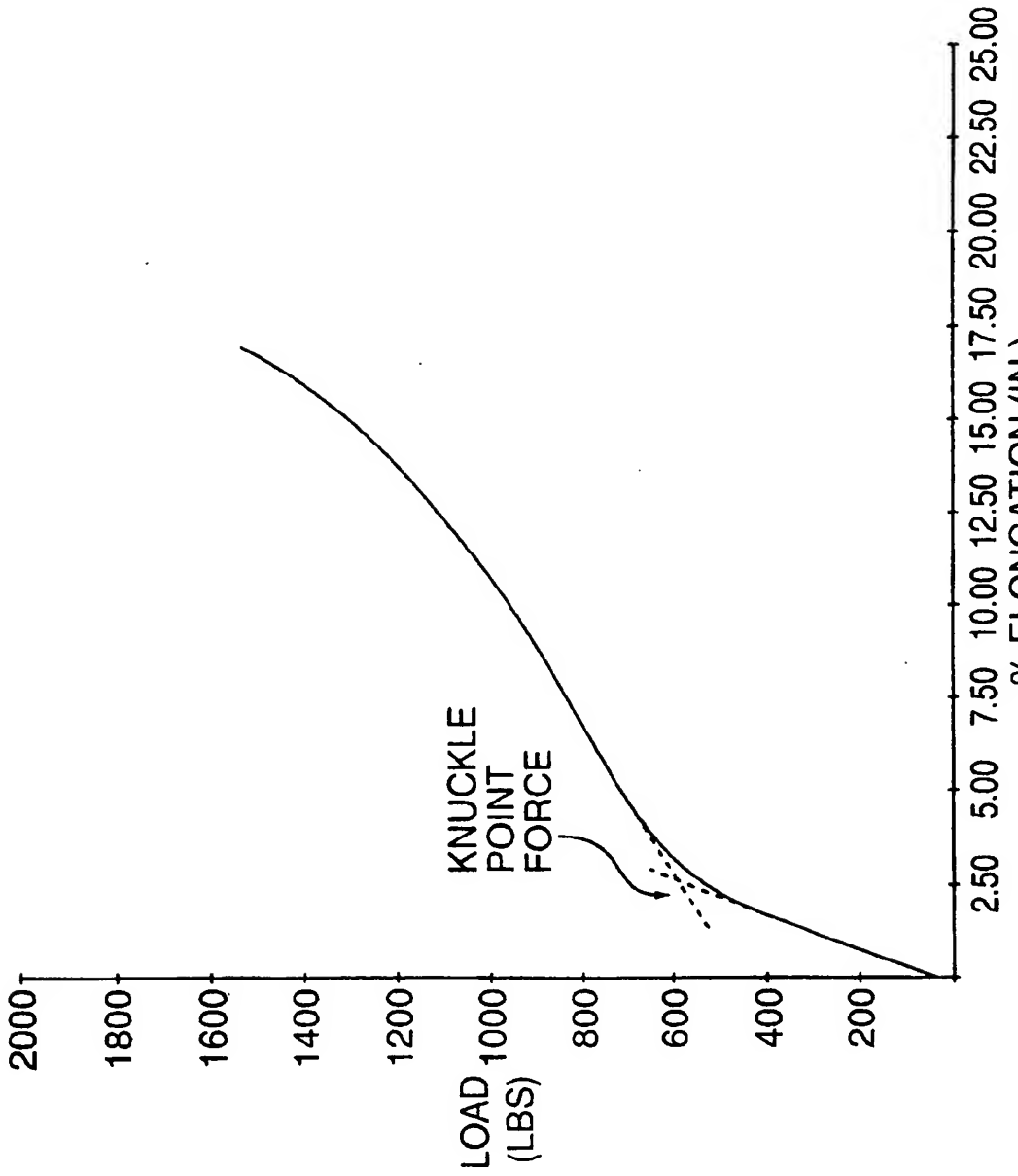

LOAD (LBS)
2000
1800
1600
1400
1200
1000
800
600
400
200
KNUCKLE POINT FORCE
2.50 5.00 7.50 10.00 12.50 15.00 17.50 20.00 22.50 25.00
% ELONGATION (IN.)

FIG. 5A